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The physiographic features
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VOL. I, 1900

THE PHYSIOGRAPHIC FEATURES OF MARYLAND

CLEVELAND ABBE, JR.

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THE PHYSIOGRAPHIC FEATURES OF MARYLAND*

BY CLEVELAND ÁBBE, JR., WINTHROP NORMAL AND INDUSTRIAL COLLEGE, ROCK HILL, S. C.

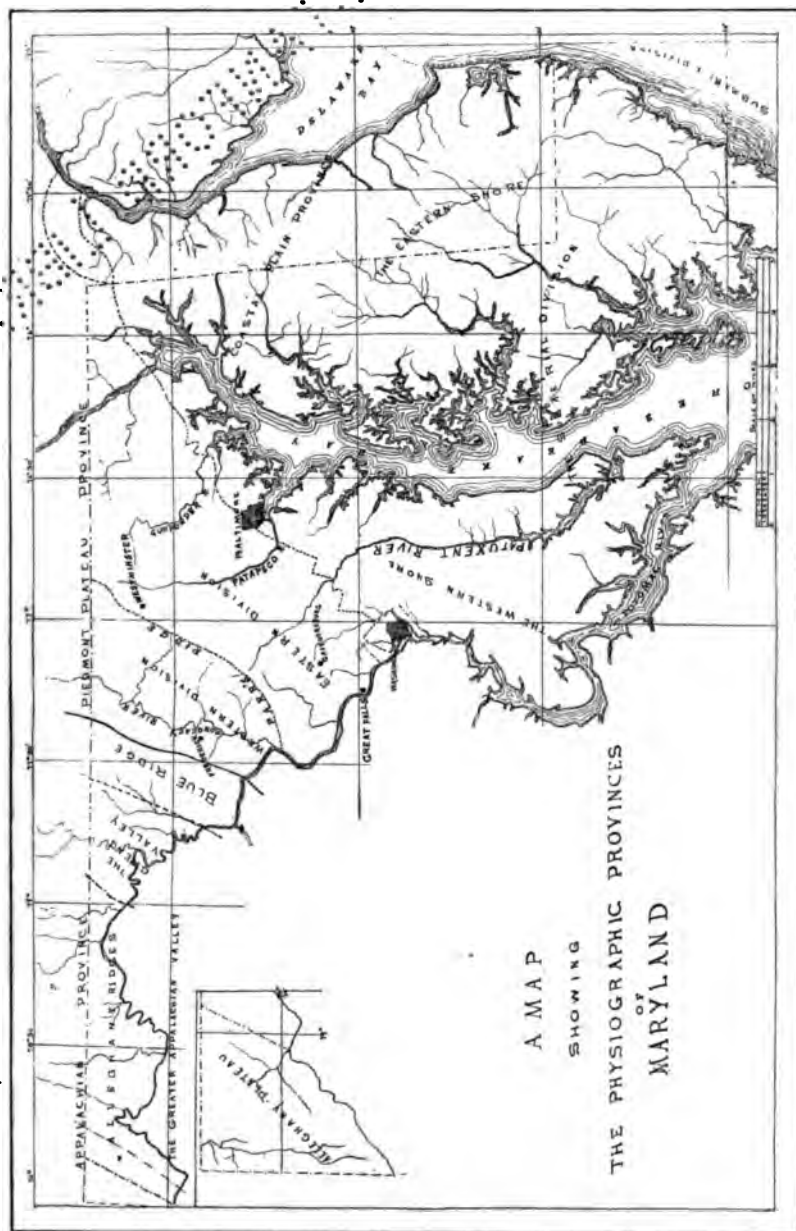
The State of Maryland extends from, approximately, the 75th meridian to west longitude 79° 30'. It thus embraces within its boundaries portions of the Atlantic Coastal Plain, the Piedmont Plateau, and the Appalachian Ranges and Plateau, the three geologic and geographic provinces of the Atlantic slope of North America. The state may, therefore, be said to present in its own varied topography, an epitome of the surface features of the whole Atlantic slope.

Of these three provinces, the Piedmont plateau is the oldest. This is shown both by comparing its highly metamorphosed crystalline and sedimentary rocks with the relatively unaltered strata of the other provinces, and by the character of its topography. From the Piedmont, in early geologic time, were obtained the materials which are now found built into the folded and faulted strata of the Appalachian regions. From both Piedmont and Appalachian districts a great volume of sand, gravel, clay and boulders, has been washed during the later periods of geological time. These materials are now found forming the youngest of Maryland's topographic provinces, namely, the Coastal Plain. These three provinces, with their several subdivisions, are shown on the accompanying map. (Fig. 1.) In the following pages the characteristics and the development of the chief surface features of these provinces will be briefly discussed.

THE PIEDMONT PLATEAU

Topography.—The oldest province, the Piedmont plateau, is divided into an eastern and a western portion by the crest-line of the divide between those streams which flow eastward by direct courses into Chesapeake bay and those which flow westward into the Monocacy. This divide is a rather flat-topped ridge which

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runs in a northeasterly direction across the state from the Potomac to a point beyond Mason and Dixon's line. It has an average elevation of nine hundred feet, rising gradually from its southern end, where it has an elevation of about six hundred feet to a maximum of nearly one thousand feet near the northern boundary of the state.



FIG. 2. THE PATAPSCO VALLEY IN THE PIEDMONT PLATEAU,
BALTIMORE CO.*

From this divide, called Parr's Ridge, the general surface of the eastern division of the Piedmont slopes gently southeastward to an elevation of about six hundred feet at its eastern boundary where it seems to pass beneath the western fringe of Coastal Plain sediments. The general appearance of this portion of the Plateau is that of a gently rolling plain traversed from northwest to southeast by a few broad, shallow valleys. Near its eastern limit a few hills and ridges are seen to rise very slightly above the general

* Illustrations in this article are furnished thru the courtesy of the Maryland Geological Survey.

surface. On looking closer it is seen that the streams have cut trenches or gorges below the general upland surface. These gorges increase in depth as they proceed eastward, and at the same time their channel profiles change from the normal concave-upward type to the less usual convex-upward type. In the excellent view of one of these stream valleys, forming Fig. 2, the foreground illustrates the character of the valley slopes as they lead down to the narrow flood plain over which the stream is now flowing. In the background the crests of the rounded hills neighboring the stream, together with other more distant elevations, are seen to merge into the even and almost level horizon line, which is characteristic of any general landscape view in this district.

Several of the smaller streams of the eastern Piedmont occupy valleys which do not belong, strictly speaking, to the tree-like branching system of most of the streams. These streams are found to be located along bands of soluble limestone whose directions are at variance with the stream-branching usually found here. Deposits of Coastal Plain sediments have been found in these peculiar, subsequent valleys, whose age is therefore fixed as intermediate between the date of formation of the general upland and that of the earlier Coastal Plain deposits.

Turning to that portion of the Piedmont Plateau situated west of Parr's Ridge, the first character of general importance that catches the eye of the observer is the change in slope of the upland surface. Instead of declining gradually and uniformly, as does the eastern upland, to the line of lowest levels, along the Monocacy, the descent is comparatively rapid for the first portion of the distance. The reason for this is clear. In the first place the total change in elevation from the divide to the lowest levels on either side is the same, approximately 500 feet; but on the east this descent is accomplished only after traversing a horizontal distance of over forty miles, while on the west the decline is made within less than half that distance. In the second place, areas of yielding brown sandstones and shales which occupy the central portion of the western division, have further narrowed the horizontal distance within which the decline takes place by extending the low levels found near the Monocacy, for several miles toward the divide.

The streams which flow westward across the more steeply sloping portion of the plateau are characterized, for a short

distance from the ridge, by somewhat narrower valleys than are found belonging to the eastward flowing streams. These valleys widen rapidly, however, as they approach and enter the sandstone areas adjacent to the Monocacy. At the same time the general surface of the plateau loses its steeper slope. It becomes almost horizontal for a distance of about eight miles, maintaining an average elevation of 500 feet above sea-level. Then the surface declines rapidly to a lower level of 450 feet where a broad terrace may generally be traced out. Along the present entrenched channel of the Monocacy runs a second and narrower terrace at a level of about 350 feet. Both the terraces and the general upland surface rise gently as they extend northward, and all are now more or less dissected by stream channels cutting across them down to the Monocacy. The channel profiles of all the streams of this district show the normal concave-upward slopes produced by uninterrupted stream growth. The grades, however, are much steeper near the heads of the streams referred to, than they are at corresponding points in the channels of the eastern division streams.

The Rocks and Structure.—The rocks of the Piedmont plateau province include fragmental and igneous rocks, in both metamorphosed and non-metamorphosed conditions. The eastern division is largely composed of altered igneous rocks which have pinched in with them bands of phyllite, slate, quartzite and marble that undoubtedly represent originally stratified rocks. On the west the rocks are largely phyllites, with included marble and limestone lenses, upon which unaltered red sandstones, shales, and limestone were deposited. These sandstones, etc., are now much faulted.

The dynamical metamorphism which the present crystalline rocks have undergone, has arranged their mineral constituents in long parallel lines and planes which bear no necessary relation to the stratification planes of the originally elastic rocks. From the east and the west the foliation planes dip steeply down towards an axial line. This line, called the axis of foliation, crosses the Potomac near Great Falls, proceeds northward past Gaithersburg and Westminster and on into Pennsylvania. On the western side the strike of the foliation and of the infolded marble lenses is northward, parallel with the axis. On the east after keeping a northeastward course as far north as Westminster, the foliation of

the gneiss and its infolded bands of marble, quartzite, etc., makes a sudden turn to the east, follows the new direction for some miles, then again turns northeastward.

Relation of Topography to Structure.—The relation between topographic forms and geologic structure is not a close one in this province. All the larger streams, including the Monocacy except for a short distance, seem to have located their courses quite independently of the arrangement of the bands of yielding and resistant rocks described above. This feature is more strikingly illustrated in the eastern division where the Gunpowder, Patuxent and Patapsco rivers are the best examples. In the western division the Monocacy shows some independence of yielding and of resistant rocks in portions of its course below Frederick, while many of its tributaries from the east are quite indifferent to the foliation and the variations in the phyllites which they cross.

The general indifference to structure shown by the courses of the Piedmont streams, coupled with their peculiarly characteristic tree-like branching patterns have led to the conclusion that the streams did not originate upon the plateau surface as now exposed. Their characters indicate that they developed their present patterns when flowing across an almost smooth and gently sloping surface such as would belong to a series of nearly horizontal marine beds deposited across the beveled edges of the present eroded crystallines of the eastern division. On the west the covering on which such courses could have been developed seems to have been the now partially removed and much faulted red sandstones of the Newark formation. On the east the cover was probably formed by a westward extension of the deposits of the Coastal Plain.

The streams have cut their channels down thru these coverings and into the formerly buried crystalline rocks, then forming the foundations. The streams were thus able to so fix their courses in the crystallines that subsequent elevation and erosion, resulting in rather widespread removal of portions of the cover, have but served to confirm them the more in their discordant positions. The majority of the present stream courses of the Piedmont are thus seen to be at variance with the existing rock arrangement or structure because they have been inherited from courses developed when those structures were quite hidden beneath a blanket of younger sediments.

THE COASTAL PLAIN

Origin.—The materials worn from the Piedmont Plateau during its later topographic development, were carried by the streams of the state into the Atlantic; and accumulating there built up a broad, flat-topped platform bordering on the shore and lying but a few hundred feet below sea-level. This submerged platform was a part of the more extensive continental shelf which was being built, during the same geological epochs, along the whole Atlantic coast of North America. Its construction seems not to have been continuous, for there are discontinuities and unconformities within its mass of almost horizontal strata, indicating that at times a portion of the shelf stood above sea-level and suffered from marine and subaerial erosion. In brief, this shelf would seem to indicate that the Atlantic coast has been alternately up and down several times during its recent geological history.

The greatest of its recent movements has been an upward one, which served to raise about one-half of the shelf above sea-level. Thus the eastern portion of Maryland is now a comparatively smooth, even, sandy or clayey plain, which has recently formed the sea floor just beyond the former shores of the Atlantic, and which may yet be traced from its dry land portion continuously to and beneath the sea for many miles. Because of its nearness to the coast, of its mild topography, and of its geological history and origin, this lowlying sandy district in eastern Maryland is called the Coastal Plain.

Boundaries and Subdivisions.—As usually referred to, the Coastal Plain is said to extend from the shores of the Atlantic on the east to the Fall Line on the west. It is evident, however, that if we consider the Coastal Plain as a geologic as well as a topographic unit,—and this we have a right to do when we bear in mind their close genetic relation—then we must include within the term Coastal Plain not only that portion of the former continental shelf which is now dry land, but also that portion which remains submerged as the present continental shelf. This paper will therefore include within the province of the Coastal Plain both that portion of the former continental shelf which has become dry land and that portion which remains submerged and extends out to about the 100-fathom line as the present continental shelf.

The western boundary proper is an irregularly waving or

crenulate line, marking the western limit of the weakly coherent beds of the Coastal Plain series where they finally disappear and reveal the more resistant crystalline rocks of the Piedmont Plateau district. As will be seen by reference to the map, this line has the general direction and position of the railroad lines between Washington, Baltimore, Havre de Grace, Wilmington, Del., etc., and is thus also closely coincident with the Fall Line.

Besides the general and obvious subdivision of the Coastal Plain province into an emerged and a submerged portion, topographic features and popular usage make desirable the further subdivision of the emerged portion which is divided by Chesapeake Bay into the Eastern Shore and the Western Shore, or, as the latter is sometimes called, the peninsula of Southern Maryland. The Eastern Shore lies between Chesapeake Bay and the Atlantic, while the Western Shore is embraced between the Potomac and the Fall Line on the west and the western shores of Chesapeake Bay on the east.

Topographic Features and their Development.—When the almost even surface of the continental shelf gradually emerged from beneath the sea and became a portion of the dry lands, its topography became the topography of the young Coastal Plain then just born. What this topography was, we can best judge by studying the present topography of the still submerged part as it is revealed by the soundings on the U. S. Coast and Geodetic Survey Charts of this region. These charts show that at present the surface of the continental shelf slopes gradually seaward and has practically no marked elevations or depressions. Near the coast the waves and currents have built up a long narrow ridge of sand behind which are the shallow tideless lagoons of Sinepuxent and Chincoteague bays; and just off the shore from this long sandy beach low swells or bars have also been thrown up almost to the level of low tide. With these exceptions however, the present submerged portion of the province is quite featureless.

Judging from this inspection of the Coast Survey Charts, then, the original surface of the emerged Coastal Plain must have been quite as monotonous; the extensive areas of original surface still remaining on the Eastern Shore, when combined in fancy with the numerous remnants found within the bounds of the Western Shore, all bear out this conclusion. In fact the Eastern Shore of Maryland is a low flat region of very even surface attain-

ing its maximum elevation, about one hundred feet, in its extreme northern portion, and descending gradually southward quite to sea-level before the southern end of the peninsula is reached. The main divide, running almost north and south, is located nearer the Atlantic than the Chesapeake Bay shore of the peninsula. The reason for this unsymmetrical location has not yet been found, but it seems to be in some way related to the location and origin of Chesapeake Bay. The divide is broad and flat, particularly where it embraces large swamps.

The streams of the Eastern Shore all show two parts to their courses: the upper portion lying above sea-level and into which the tide never comes, and the lower tidal or estuarine portion bordering either the Chesapeake or the Coastal lagoons. Short and insignificant as are the eastward flowing streams of the peninsula, they still show this two-part character. In their upper courses all the streams show small volumes of water flowing thru rather shallow and open valleys. As the streams draw nearer tide water, the valley slopes usually become slightly steeper while the valley floor broadens and flattens a little. Beyond the limits of tide water, the channels and valleys do not appear to be so markedly meandering; but as soon as the valleys become subject to the daily tide, being half filled and half emptied every day, the crooked character of the stream courses is clearly brought out. All these lower courses are characterized by broad tidal flats of varying widths confined by steep banks which often show wave and tide-cut cliffs twenty to forty feet in height.

As is to be expected, there are no well marked sea-cliffs or wave-cut cliffs on the bay side of the Eastern Shore, for its shores are as a rule too low. On the contrary, the mouths of the tidal estuaries frequently become confused in the maze of low-lying and swampy or boggy islands which fringe this side of the peninsula. These islands are gradually wearing away under the slow attack of the relatively weak waves sent against them; and the brackish waters of the bay are gradually finding their way to the roots of the pines growing on many of these islands, with the result that many trees are dying. The whole character of topography and stream-courses on the Eastern Shore is thus seen to suggest that, after being elevated sufficiently to permit the streams to carve, or rather to begin to carve, a very mild topography, the district was then partially submerged so that the tide now runs far inland from

the Chesapeake Bay side, but only for a short distance on the Atlantic side.

Crossing Chesapeake Bay to the Western Shore, or the peninsula of Southern Maryland, there is a decided change in topography and in shore-line characters. The original surface of the Coastal Plain has here been raised much higher above sea-level, the average elevation being about three hundred feet for the inter-stream areas. By reason of this greater elevation, the streams of this district have been, and still are, able to cut their valleys much deeper than are the streams of the Eastern Shore. It is not surprising, therefore, to find that the original surface is now much cut up into long flat-topped ridges and small table-lands forming rather immature divides between valleys which are, in some cases, wide and alluvially floored, but always steep-sided, even when they are not bounded by steep cliffs as is the case in the lower portions of most of them.

In some cases these flat-topped divides are the resting places for the rain that falls upon them, as is clearly shown by small, boggy sections which may be found on inter-stream areas not very far from Washington city, D. C. In certain instances, notably that of divides for streams running into the Potomac on the one hand and the Patuxent on the other, the divides do not hold their well-marked and sharp crests evenly balanced between the two main streams, but have pushed over farther to one side than the other. In the instance mentioned, the crest-line stands nearer the Patuxent than the Potomac. This lack of symmetry in location of divides has yet to be satisfactorily explained. In some instances it may be due to local tilting; in another instance it certainly can be explained, in part, by the erosion of the waves in the bay wearing back the cliffs more rapidly than the streams on the western side of the little peninsula have been able to wear down their upper valleys.

All the valleys of the Western Shore, which belong to streams of any size, present along their lower courses in particular good illustrations of river terraces. Most of the streams show two sets of terraces, and so far as the study has been carried, it would appear that, in the case of those streams which flow from the Piedmont Plateau out across the Coastal Plain, these two terraces can be correlated with more fragmentary ones found along the Piedmont portion of these valleys. The terraces in the Coastal Plain province

are regarded as indices of the depths to which the rivers were submerged during a partial subsidence, which seems to have occurred after the last great emergence gave opportunity for the streams to carve out valleys of considerable depth in the yielding Coastal Plain strata. These subsidences, succeeded by emergence and further cutting, as the terraces indicate, have finally been followed by depressions of less amount, which have partially drowned the lower courses of the rivers, admitting tide water as far inland as the Fall Line. Since this final subsidence, the smaller streams of the Western Shore have shown a distinct tendency to shoal their lower courses during the past one hundred and fifty years. This may indicate another earth movement in an upward direction, or it may simply mean that in spite of continued subsidence the supply of debris by the streams is too great for the weak tidal currents of the smaller creeks to carry away. Altho the amount of debris brought into those creeks now filling up, seems to be rather small, it may be that the latter is the true explanation of the phenomenon.

In concluding the chapter on the Coastal Plain, some space should be given to the origin of Chesapeake Bay, and the reason for the Fall Line. As the young marine plain gradually emerged from the Atlantic and became the "emerged Coastal Plain," those streams which had originally emptied from the Piedmont and Appalachian districts into the Atlantic farther westward, were constrained to extend their lower courses carrying them out gradually as the new forming land grew wider and wider. At the same time the rains falling upon the new land, and finding it to possess a nearly uniform seaward slope, were gathered into new streams, which headed altogether within the limits of the Coastal Plain and flowed across it to the new shore-line. To that class of rivers which merely extended their lower courses across the new land, following down its steepest slopes, seaward, belong the Susquehanna, the Delaware, the Potomac, perhaps the Patuxent, and the Gunpowder. All the streams of the Eastern Shore belong to what we may style the new or original streams to distinguish them from the old extended streams of the first class. Both classes of streams, in following consequent courses upon the mildly sloping new land surface, were probably easily influenced by slight irregularities of surface, and also by any decided coast-wise currents which may have existed.

Both the Susquehanna and the Potomac follow courses which

suggest that they met some kind of barrier, some deflecting force which turned them southward for a long distance before they could regain their normally southeastward courses to the Atlantic. Some have suggested that this deflection was due to a strong southwesterly current setting along the coast, which built along it parallel off-shore beaches and bars, such as characterize the present coast, and thus compelled these large streams to turn parallel to the coast for some distance. Another suggestion is that the last great elevation of the Coastal Plain broke it into two blocks which tilted towards each other, causing a trough where Chesapeake Bay now is, along which both streams had to run before breaking out to the eastward. The present state of our knowledge of those Coastal Plain strata which hold the key to this question, does not permit of a definite conclusion being given for Maryland. It is clear, however, that the Susquehanna did not succeed in carrying its course across the emerging sea floor in the shortest path, but was turned southward. In this anomalous path it cut a deep valley and developed some fair-sized tributaries on either side of it. Recent submergences, above referred to, have drowned the Susquehanna up to Havre de Grace. So has come into existence the long, comparatively narrow and shallow Chesapeake Bay, bounded on the west by tall, wave-cut cliffs, where the waves of northeast storms get full play against the land, while on the east or lee-shore are low-lying islands and intricate creeks with low tongues of land between them.

To return to the extended and the original Coastal Plain rivers. As these streams cut their valleys down thru the rising wedge of Coastal Plain sediments, they found that all portions of their courses were not similarly situated as concerned the amount of work they had to do. The far down stream courses found that they soon could cut their way down to their base-level, the level of the Atlantic, and that when they had done so, the yielding Coastal Plain strata still lay beneath, and on either side of them. So they were able to wear their channels to a very low slope, or grade, in a short time, and then began to swing about from one side to the other gradually widening the valleys. Far up-stream, however, these same streams found that they had to cut thru resistant, Piedmont, crystalline rocks beneath the yielding Coastal Plain strata, long before they succeeded in reducing these portions of their channels to sea-level. Indeed, this they have not yet done,

as is shown by the falls and rapids in their channels. The transition from the low, gentle grade of the down-stream channel to the steeper, rocky, up-stream grade is very sharp. The point where it is made is always recognizable as that point below which there are no falls or rapids, above which the channel is full of them. This transition point is also the head of navigation on the stream. If these points of change in grade, determined for each river, are all connected, the line thus drawn is then called the Fall Line, since every stream crossing that line changes the character of its channel from a smooth, even path below, to a series of falls or rapids, above.

THE APPALACHIAN PROVINCE

Boundaries of the Province.—The Appalachian Province of Maryland embraces what is commonly known as Western Maryland. The eastern boundary of the province is formed by Catoclin mountain, while the western limit is artificially defined by the western boundary of the state, altho topographically and structurally the province continues westward until it merges gradually into the lowlands of the Ohio drainage. To the north and south the topographic features of the province reach far beyond the limits of our state. The broad lowland of the Great Valley and the many parallel, even-crested ridges with intervening valleys, which are so characteristic of the province, extend from central Alabama and Georgia northward thru Maryland and across Pennsylvania until they disappear in the plateau country of southern New York.

General Topographic Features.—The topography of the Appalachian Province is more varied, more picturesque and grander than that of either of the other two provinces. In its eastern part the broad and somewhat serrated crests of the Blue Ridge and Catoclin mountains overlook the broad, gently rolling floor of the Cumberland or Hagerstown valley, which is watered by Antietam and Conococheague creeks, streams of some size that have sunk meandering trenches to depths of seventy-five or eighty feet below the general level of the valley floor.

Beyond the Great Valley may be seen the long, even crest of North Mountain. This strongly marked topographic feature is the most easterly of a series of long, parallel mountains running northeast-southwest and alternating with long, narrow valleys. These ridges and valleys are the chief topographic features of the district

between the Great Valley and Dans Mountain west of Cumberland. They are termed the Appalachian Ridges and have been classed under that name as one of the sub-provinces of the Appalachian Province on the outline map. Beyond these ridges, which gradually increase in height westward, the general surface spreads out as an extensive upland or plateau with an average elevation of 2,500 feet, from which parallel ranges of mountains rise.

The Present Structure of the Province.—In describing the Piedmont Plateau it was pointed out that its topography was closely related to the geology. The Appalachian Province shows in a yet more striking manner this relationship between geology and topography since the winds, rains and rivers have been at work for ages etching out the mountains and valleys along the lines determined by the structure of the country. The hills and the mountains all indicate by their parallel arrangement and N. E.-S. W. trend that the resistant rocks cross the state in the same direction, while the valleys tell the same story about the location of the less resistant formations. A cross section of this Province shows that the strata have been thrown into folds whereby at certain points hard resistant conglomerates and sandstones have been brought to the surface, while at other points they have been thrust deep down and only the more yielding rocks above them appear. Many of the smaller ridges and even elevations such as Wills Mountain, mark lines along which some hard, resistant stratum has been arched up. Such ridges have their general cross profile determined by the arched strata which maintain them. Other prominent ranges, such as the Blue Ridge, owe the elevated position of their resistant rocks to great dislocations along which the rocks have been thrust up above their earlier positions.

Between the original ridge-forming folds or anticlines there were valley-forming troughs or synclines, in which it is probable that the rains gathered and formed streams which would be classed as consequent. Today a number of small streams occupy similar positions among the ridges and mountains of Washington county. It is not likely, however, that these present streams have inherited their courses from consequent ancestors. On the contrary, since the synclinal troughs are occupied by yielding shales, it is much more likely that the streams took courses immediately above their present locations during the time when this whole district was being reduced to the general surface of the Schooley or Cretaceous

penepplain. During that period of erosion the summits of the present hard ridges appear to have acted as guides directing the streams to develop along the more easily eroded strata of the synclines. In many cases the arches of hard rock originally rose so high above sea-level that they were truncated by the broad, gentle surface of the penepplain, as it was gradually but irresistably extended across the folds. The domes of rock were thus completely unroofed and their cores of softer rocks became exposed to the attacks of the elements. Guided by the easier paths thus opened, certain rivers extended their courses, not along constructional troughs or synclines, but along the axial lines of the arches or anticlines. Along the axis of a comparatively broad flat anticline in Garrett county the two branches of the Savage river have thus opened the broad depression lying between Savage and Meadow mountain.

Original Structure.—The gradual change from the much disturbed strata of Washington and Allegany counties to the almost horizontal arrangement of the same strata in the plateau districts of Garrett county and of West Virginia, serves to remind the observer of the original positions of these beds. The successive layers of finer and coarser materials, the remains of animals and plants, and the close resemblance between many members of the series and various deposits which may be seen forming today, all point to the conclusion that these strata were deposited in succession over the floor of some very ancient sea. All the present dislocations of those ancient strata are the products of folding and faulting under compression, which came after the rocks were laid down as horizontal beds of clays, sands, and calcareous muds at the bottom of the interior Paleozoic sea.

The Appalachian and the Coastal Plain Structure Compared.—The strata now forming the Appalachians were deposited in more or less proximity to a shore or coast which lay along the eastern limits of that ancient sea. The general location of this ancient land area, as indicated by the sediments derived from it, seems to have been in the district now occupied by the eastern Piedmont Plateau and western Coastal Plain province. In the period during which the Paleozoic strata were deposited this province was a more or less lofty land area, whose rivers flowing westward, carried down large quantities of detritus to the sea. As the amount of materials thus transferred from land to sea floor increased, the sea itself would have been largely filled up had not the lands beneath the sea

gradually subsided. In this way there was accumulated the great series of Paleozoic strata which stretched far westward from the coast of that time.

If now the strata deposited in this Paleozoic sea are compared prior to their dislocation, with the present Coastal Plain series, several points of resemblance, particularly as regards origins and relations to the mainland, may be pointed out. Both the Paleozoic and the Mesozoic-Cenozoic sediments were deposited in seas often comparatively shallow, but which, altho constantly filling with new materials, were also for a while gradually deepening, thus continuing the period of deposition. Both series of sediments were derived not only from areas immediately bordering the respective basins of deposition, but also in part from precisely the same region, namely, the Piedmont district. These comparisons show that during long periods in geological history the Piedmont region has been supplied with a Coastal Plain.

Topographic Subprovinces.—It is clear from the general description of the Appalachian Province given above, that a four-fold subdivision is possible on the basis of the topographic types represented. These subdivisions from east to west may be designated as the Blue Ridge, the Great Valley, the Alleghany Ridges and the Alleghany Plateau.

The Blue Ridge.—The physiographic subprovince here designated by the name of the Blue Ridge includes the Blue Ridge proper, the Catoclin mountain and the district lying between them. Blue Ridge proper, which forms the western boundary of the subprovince, is a long, straight ridge with slightly uneven and knobby crest maintaining an average elevation of two thousand feet above tidal level. It starts in Pennsylvania as a portion of South Mountain, passes southward thru Maryland and after declining somewhat on each side of the Potomac gorge at Harper's Ferry, rises again in Virginia to a somewhat lesser elevation. That portion which lies within the limits of Maryland owes its crest line altitudes to the superior resistance of the Lower Cambrian or Weverton sandstone which reached its present elevation partly as the result of a great overthrust fault, partly thru more recent elevations of the whole of the Appalachian district.

Altho subsequent denudation has carved numerous scars and slight sags in the crest of the Blue Ridge, except for the narrow

defile of a small branch of Antietam creek debouching at Leitersburg, the Ridge presents an unbroken crest from Gettysburg Gap on the north to the deep gorge of the Potomac at Harper's Ferry. The western slope of the Blue Ridge divide has the greater relief, its summit rising about 1,500 feet from the level of the Cumberland or Hagerstown Valley. The contours of this slope are generally precipitous along its upper zones. Over the lower portion they become much softened, however, and grade into low, rounded foothills which mark the outcrop of a band of fissile shales, Harper's shale, lying between the quartzite and the limestone. The eastern slope of the South Mountain is much milder in slope than is the western face for two reasons: First, because the capping sandstone dips eastward, and second, because there is but slight difference between the resisting powers of this sandstone and of the volcanic rocks lying against it on the east.

East of the Blue Ridge proper, and almost parallel with it, runs the straight and slightly undulating ridge called Catoctin mountain, which forms the eastern boundary of the Blue Ridge subprovince. Its prominence is due to the greater resistance of the heavy Cambrian quartzite, which has withstood the attacks of the elements more successfully than the rocks on either flanks. Again it is with the Catoctin as with the Blue Mountain, that that slope which descends to the yielding rocks of the broad valley lowlands, is the longer and the more precipitous, while the opposite slope is the milder and the shorter. Here, however, the valley lowland is that of the Frederick or Monocacy valley carved out on the Frederick limestone and the Newark formation. This lies to the east of the ridge, while the shorter and milder decline forms the western slope.

Turning now to the valley included between the two crests just described, it is found that this portion of the Blue Ridge subprovince has a number of peculiar and interesting features. It attains its best marked and most characteristic development in the southern portion of the district, in the drainage basin of the Catoctin creek, and is less characteristically a valley in the northern half of the area which is drained by the Monocacy and Antietam tributaries. In spite of the fact that nearly half of the drainage basin of Catoctin creek is underlain by igneous rocks, like granite and quartz porphyry, and the remainder by the still more resistant Catoctin schist, the stream has reduced a considerable portion of

its basin almost to a base-levelled state during a geographically recent period. Starting with an average elevation of about five hundred feet over that portion of the valley lying along the Potomac, the old valley floor may be traced northward a little beyond Myersville, where it has reached an elevation of about 750 feet. A considerable part of this rise is accomplished within the last ten miles where it is accompanied by a growing irregularity in the old valley surface. This gradual change in perfection of modelling is what would naturally be expected over the up-stream portion of an old valley, since the lower portions of a stream's course are always found to be reduced more perfectly and uniformly than are its up-stream limits. Beyond Myersville the traces of this old valley floor are quite lost, if the feature ever existed there. Below the more or less even surface of what may be called the five hundred foot level, the Catoctin and its tributaries have incised their channels to depths up to a hundred feet, according as they are farther from or nearer to the present local base level, the channel of the Potomac river. Above the general five hundred foot level there remain a few areas not wholly reduced. These are more numerous along the sides and particularly at the head of the basin where they gradually merge with that portion of the area which never was reduced to the five hundred foot plain.

The northern portion of this district, lying between the crests of South Mountain and Catoctin, seems never to have been reduced to such a valley lowland as formerly existed along Catoctin creek. The combined action of the resistant rocks to the north, and the superior powers possessed by the headwaters of Catoctin creek working up from the south has, so far, resulted in confining the drainage of the northern streams within comparatively narrow bounds. Altho the volumes of the latter streams have thus been limited to such meagre proportions, small subsequent streams and valleys along the comparatively yielding quartz-porphyries have been developed, and today there may be seen green, level-floored, narrow valleys winding in and out among numerous bluntly conical hills or long ridges. Below these valleys, particularly near the mountain fronts, the torrent-like streams have often cut steep, wild gorges.

The Greater Appalachian Valley.—The Greater Appalachian Valley embraces all the country lying between the Blue Ridge on the east and Dans Mountain or Alleghany Front on the west, and

thus has a width of about seventy-three miles. As has been noticed above, the Greater Valley admits of a two-fold sub-division into the Great or Cumberland Valley on the east and the zone of the Alleghany ridges on the west.

The Great or Cumberland Valley is the rather broad, even depression lying between the Blue Ridge on the east and the North Mountain on the west. This broad fertile valley, sometimes known as the Hagerstown Valley where it passes thru Maryland, is a marked topographic feature thruout the whole extent of the Appalachian province.

The principal topographic feature of the Great Valley is its broad, gently rolling floor. Altho this floor is now much cut up by minor drainage lines, its formerly almost level surface has given the present hills very strikingly accordant elevations. So nearly coincident are the various heights that if a flat board floor could be laid across the valley, it would be supported by almost every hill and would have an altitude of about six hundred feet above sea level. Long divides with broad tops maintain this average elevation over considerable distances, and are generally occupied by highways. There is a slight descent from the northern boundary of the state to an elevation of from five hundred to 550 feet along the Potomac, which brings this former plain into relation with the plain along the Catoctin creek and the Monocacy river.

The principal streams draining the Maryland section of the Great Valley are Antietam and Conococheague creeks, both of which rise in Pennsylvania and flow southward thru Maryland to the Potomac. The valleys of these streams are deep, narrow and steep-sided, that of Conococheague creek being particularly gorge-like in character. The streams themselves are rather rapid and have not yet reduced their channels to even grades, as is shown by the low ledges of shales and limestone which sometimes interrupt their flow. The courses of the channels are tortuous, often quite meandering, and these turns and twists are always followed by the gorge walls. This fact indicates that the streams originated their meanderings on the flood-plains which accompanied them when the present dissected valley floor stood at a lower elevation and these streams flowed upon its continuous surface. As the area was elevated the streams began to cut down along their courses, always keeping a little behind the Potomac, as it deepened its channel. Thus the winding courses which the streams followed on their

earlier flood-plains became impressed upon the limestone and shale beneath, and these more resistant rocks still retain the streams in their old courses which are described as inherited or superimposed.

The general characteristics of the Alleghany Ridges have already been briefly sketched. Several of these ridges are due to the up-arching of resistant sandstones which have withstood the attacks of the elements, while the yielding rocks which covered them have given away. The best examples of such prominences are found in Wills Mountain, Martin's Ridge, Warrior's Ridge and North Mountain. The dome of the arch in the latter case has been partly removed, however, and the yielding shales beneath, which were formerly protected, are now rapidly giving away. There is thus forming a shallow and elevated valley along the axis of the up-lifted trough. All of these mountains rise very nearly if not quite to the two thousand foot level.

Other crests, such as those of Town Hill, Sideling Hill, and Tonoloway Hill, fail to reach this height by about five hundred feet. They owe their elevation to the fact that, in a number of cases, the Carboniferous conglomerate or sandstone was depressed below the general level of the Schooley peneplain, and thus escaped being worn away during the production of that feature. Subsequent elevation and erosion have removed the softer rocks, which were then exposed by the unroofing of the arches or anticlines; and these small synclinal remnants of the hard sandstones now stand out in relief as protecting caps to the yielding strata just beneath them. Thus what may have been, originally, a series of constructional synclinal valleys has been converted into a set of parallel even-crested ridges with synclinal summits.

Between these mountains and ridges comparatively broad, even-floored valleys were at one time carved out by the streams which had reached the anticlinal arches during the Mesozoic era. For so long a time did the land stay at rest after the elevation of the Schooley peneplain that these streams reduced their valleys to very gentle slopes, even far back in among the ridges. Sufficient time, however, was not allowed for the reduction of the ridges also, as was the case during the preceding cycle. It was at this time that the level floor of the Great Valley was produced, the general surface of which can be followed in and out among these western ridges. This generally even and accordant surface is often referred to as the Shenandoah Plain, because it is so typically developed

over the yielding rocks of the Shenandoah Valley. Having been developed only in the vicinity of the streams, the Shenandoah Plain is found to rise gradually as it extends towards the headwaters of the various mountain streams of the central district. The general elevation, however, is somewhat greater and the inclination of the surface steeper than would be the case if due simply to the normal stream slope of the region. These features are believed to be due to a general but unequal elevation of the land after the Shenandoah Plain has been developed. This elevation, or more strictly speaking, warping, was greatest along a northeast-southwest axis located near the eastern boundary of the Alleghany Plateau, and also along a minor axis running southwestward from southern Virginia and West Virginia, the influence of which was extended as far northward as Maryland and eastward to the Atlantic coast line, affecting to some extent the district of the Alleghany ridges.

The warping of the Shenandoah Plain exerted a marked influence upon the development of the well-adjusted streams of the Appalachian district which, at the close of the period of denudation, were meandering over comparatively broad flood-plains. The elevation which succeeded the period of denudation revived the activities of the streams, and they rapidly deepened their channels, cutting narrow winding courses, taken from their former directions on the Shenandoah Plain. Continued denudation has now worn away considerable portions of the inter-montane region, so that its general surface can be traced only in the long, flat inter-stream areas and the rounded crests of those hills which rise to the general level of the plain.

Among the most characteristic remnants of this formerly extensive surface may be mentioned Shriver's Ridge, with an elevation of 1,071 feet; the northern spur of Knobbly Mountain across the Potomac river, with an elevation of 1,115 feet; the heights northeast of Cumberland, with an average elevation of something over one thousand feet; and the broad, dissected district extending northward from Old Town, which is drained by Big Spring run and Town Creek, with an average elevation of about nine hundred feet. The character of the gorges which the streams have cut below the uplifted Shenandoah Plain clearly shows that the rate of elevation was not uniform. At least three distinct terraces can be made out along the banks of the Potomac

in the vicinity of Cumberland. Each terrace indicates a period of temporary quiescence for the land, during which the stream was able to expend some of its energy in the horizontal cutting and widening of its channel; while each slope from a higher to a lower terrace indicates a period of renewed activity in vertical down-cutting. The two upper terraces belong to the class of stream-cut terraces, as is shown by the fact that their almost horizontal tops are bevelled across the upturned shales. Only a very thin layer of scattered cobbles and gravels is found on either terrace. The lower terrace is so heavily covered with river deposits of sand, gravel and boulders that it is difficult to say whether it is a cut or a built terrace or a combination of both. These terraces, particularly the two lower ones, may be followed down the Potomac beyond Harper's Ferry, running in and out of the stream valleys which join that river from either side and gradually declining in elevation. Up-stream they have been traced as far as Keyser and undoubtedly extend a considerable distance further. Attempts have been made to correlate these terraces with contemporaneous epochs of deposition contained within the Coastal Plain series, but very recent work in that group of deposits by the New Jersey and Maryland surveys has so altered former conceptions of stratigraphic sequences and conditions of deposition that it seems best for the present at least not to attempt a statement regarding the stratigraphic equivalents of these features.

The Alleghany Plateau.—The Alleghany Plateau extends from northern central Alabama, where it is known as the Cumberland Plateau or tableland, northward and eastward thru Tennessee, Kentucky, Virginia, West Virginia, Maryland and Pennsylvania into New York, where it forms the high lands covering the southern half of the state from the Catskills to Lake Erie. This plateau, which preserves, in its general level, the largest continuous areas of the Jura-cretaceous, or Schooley peneplain, is not characterized by a broad, unbroken expanse, but has been so deeply dissected that only the even crests of isolated ridges remain to indicate the former extent of the plateau. Standing on some lofty central point, such as the crest of Keyser's Ridge in Garrett county, one may see all about him these long level-topped crests which seem to rise very nearly to the same height, altho there is a gradual decrease in elevation northward and eastward from the district between Savage Mountain and Keyser's Ridge. The long ridges are

arranged in almost parallel ranks and follow the broad curves of the Appalachian system, while their even crests are the present representatives of that broad peneplain which has already been referred to in dealing with the eastern portions of Maryland. The most representative elevations of the peneplain in this district are found in Savage Mountain, which has an altitude of about three thousand feet, in Keyser's Ridge and Negro Mountain, with elevations of three thousand feet, in Winding Ridge three thousand feet, and Hoop Pole Ridge 2,800 feet. These elevations are the culmination of the westward rise of the Schooley peneplain in the latitude of Maryland. Farther westward the general surface gradually declines to the Ohio and the Mississippi rivers. Within the Maryland portion of the plateau the strata are still gently folded, so that the extension across them of the old peneplain surface here, also, resulted in the removal of several rock domes. Thus, while the land was being reduced to very mild topographic forms, the way was being prepared for the easy carving out of lofty mountain ranges during a subsequent time. As a result of the elevations which have taken place since the Schooley peneplain was produced, the streams which have developed on that surface and whose courses were adjusted to its underlying structure, have deepened their valleys considerably. There were other streams, however, which, altho they occupied courses located on yielding rocks, had carved their valleys out along synclinal axes and have not since their elevation materially deepened their valleys.

There are thus seen to be two classes of valleys and streams within the boundaries of the Maryland portion of the plateau, one class has synclinal or consequent streams and valleys, the other class embraces the subsequent or anticlinal streams. The characters of these two classes of valleys are quite as distinct as are their relations to the structure. The subsequent streams have developed their courses generally along Jennings and Hampshire shales, which formed the cores of anticlines whose domes were roofed by the resistant Pocono sandstone. The elevation which interrupted further development of the Schooley peneplain gave all these streams increased activity and they began to actively reduce their valleys to the new base-level.

Today the new valley-floors thus produced may still be seen as flat-topped hills of Hampshire and Jennings shales bounded by steep and often precipitous cliffs which are capped by rocky crags

of Pocono sandstone. Perhaps the largest area covered by this surface of denudation is to be found in the vicinity of Accident. This town is located near the centre of a broad amphitheater, whose boundaries are the curving Pocono-capped crests of Winding and Keyser's ridges, and whose floor is a very gently rolling surface, large portions of which remain over the inter-stream areas. This is the old floor produced just after the elevation of the Schooley peneplain. Numerous disconnected areas along the northwestern flanks of the Savage river valley also preserve this surface. Turning to those streams which pursued consequent or synclinal courses, it appears that instead of occupying deep valleys with steep bounding slopes, their valleys are comparatively shallow and stand at higher levels than do the subsequent valleys. The best example of this class of streams and valleys is found in the valley of the Castleman river. This stream is located on that portion of the Fairfax formation or Barren Measures, which reposes in the synclinal basin between Meadow and Negro mountains. The valley is very broad and comparatively shallow, especially at the southwestern end of the syncline, and there is no sudden break in the slope from the crests of the two limiting mountains to the axis of the valley. The reasons why the streams draining such valleys as that of the Castleman river have never been able to reduce those valleys successfully is due to the fact that the whole valley is floored with a resistant conglomerate or sandstone, which must all be removed before the mountain can be lowered.

Just here it may not be amiss to refer to those broad, wholly enclosed valleys whose meandering streams are often bordered by rather marshy ground. Such valleys are known in Garrett county as "glades", while any valley which has steep bounding slopes and slightly marshy flood-plain is called "glady country." These poorly drained areas are calculated to attract attention in a district where the sharp relief of the country in general insures unusually well-drained soils. To one familiar with the poor drainage of the glaciated districts of the United States, glaciation at once offers itself as an explanation of this topography. There are, however, none of the other signs of glaciation, such as transported boulders, striated ledges or morainic material. They may be more rationally explained as products of long continued stream-action limited by very resistant local baselevels of Pocono sandstone.

So far the Maryland streams of the Alleghany Plateau have

been considered from their purely local relations. It is interesting to consider briefly their general relations to the broad structural features of the region. From this point of view, also, there are two classes of streams here: First, those which flow westward down the general dip of the strata to the Ohio, and second, those which flow eastward against the general dip to the Atlantic. The Youghiogheny and Castleman rivers take out all the Ohio drainage, while the Savage and the North Branch of the Potomac lead off the waters which flow into the Atlantic. It has already been pointed out that the whole Appalachian district formerly bore the relation of a coastal plain to a land area lying somewhere to the east. In the view of this fact all the rivers should naturally flow westward down the inclination of the strata towards the old sea. As a matter of fact, only the Youghiogheny and the Castleman approach to this arrangement, while the Potomac and its tributary, the Savage, go in directly the opposite direction. They even do more, for they cut across what we can see of that old land area and empty into the Atlantic at a point where formerly there may have been hills.

General Topographic History of the Province.—The topographic history of the Appalachian Province may be briefly summed up as follows: The Province originated as a coastal plain along the western shores of some ancient land area, part of which may be represented in the ancient crystallines of the Piedmont Plateau. Probably a short time before the close of the Paleozoic this coastal plain was elevated and deeply folded in its eastern portion by powerful compression. This elevated and corrugated coastal plain then suffered a partial reversal of its westward flowing drainage, and remaining for a great length of time in a quiescent state, was so far reduced by erosion as to attain the mild features of advanced topographic maturity and perhaps even become a peneplain. This period of repose was closed by a decided warping of the new surface, that raised it to an elevation of about two thousand feet in Western Maryland, but only to about three hundred feet in the central portion of the state. Then followed another period of repose during which the Shenandoah Plain was carved out. Finally a series of elevations at irregular intervals has warped the two plains still further, bringing the Schooley peneplain level to altitudes of three thousand feet in the western and five hundred to eight hundred in the central section of the state, while the Shenandoah Plain stands at one thousand feet to 1,500 feet in the west

and five hundred in the central district. The latest elevations have caused the streams to cut below the level of the Shenandoah Plain a series of steep, terraced gorges that they are still deepening.



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